
Studies of Socotran birds II.

One, two or three species: towards a rational taxonomy for the Golden-winged Grosbeak *Rhynchostruthus socotranus*

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Études des oiseaux de Socotra II. Une, deux ou trois espèces: vers une taxonomie rationnelle pour le Grand-verdier à ailes d'or *Rhynchostruthus socotranus*. *Rhynchostruthus*, généralement traité comme monotypique, est un de ces genres de fringillidés de l'Ancien Monde taxonomiquement énigmatiques dont la parenté a intrigué les systématiciens depuis longtemps. En utilisant des données de la morphologie et des mensurations, nous avons examiné les limites spécifiques du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*, qui a été traditionnellement traité comme une espèce polytypique, comprenant trois taxons: la sous-espèce nominale *socotranus* sur l'île de Socotra, *louisae* dans le nord de la Somalie, et *percivali* en Arabie du sud. Récemment, Fry & Keith (2004) ont toutefois suggéré que deux espèces devaient être reconnues à l'intérieur de ce genre: *louisae* sur le continent africain et *socotranus* (y compris *percivali*) en Arabie et à Socotra. Notre analyse indique que jusqu'à six caractéristiques de plumage peuvent être utilisées pour séparer les mâles des trois taxons (dont trois sont diagnostiques et les autres quasiment diagnostiques), et cinq caractéristiques pour distinguer les femelles (toutes les cinq diagnostiques). Des données morphométriques soumises à l'Analyse en Composantes Principales indiquent que les trois taxons, et surtout les mâles, sont plutôt mieux séparés au niveau de la taille et des proportions qu'on ne le pensait jusqu'à présent. A certains égards les oiseaux de Socotra ressemblent davantage aux populations d'Arabie (principalement par la présence d'une tache blanche sur la joue), qu'à *louisae* du continent africain, mais ils sont néanmoins faciles à distinguer de ces deux derniers. Ceci n'est pas surprenant quand on pense que la plupart des taxons aviaires endémiques de Socotra sont soit réellement uniques (c'est-à-dire des espèces) soit probablement à traiter comme des synonymes de formes africaines (Kirwan in press a,b). Bien que nos résultats exigent un examen moléculaire, ils suggèrent assez bien qu'il s'agit de trois allo-espèces, peut-être même trois espèces à part entière, si on se base sur la définition du rang d'espèce de Helbig *et al.* (2002); les arguments en faveur de la reconnaissance de plus d'une espèce sont légèrement plus faibles si la méthode quantitative de Collar (2006, à détailler par Collar *et al.* in prep.) est utilisée. Nous recommandons que *R. socotranus* soit dorénavant traité comme trois espèces ou une seule, mais suggérons que la reconnaissance de deux espèces à l'intérieur du genre est une sur-estimation ou sous-estimation de la biodiversité.

Summary. *Rhynchostruthus*, generally treated as monospecific, is one of a number of taxonomically enigmatic Old-World finch genera whose close relatives have long intrigued systematists. Using morphology and morphometrics, we investigated species limits in the Golden-winged Grosbeak *Rhynchostruthus socotranus*, which has traditionally been viewed as a polytypic species comprising three taxa: nominate *socotranus* on the island of Socotra; *louisae* in northern Somalia; and *percivali* in southern Arabia. Recently, however, Fry & Keith (2004) suggested that two species should be recognised within this genus: *louisae* in mainland Africa and *socotranus* (including *percivali*) in Arabia and Socotra. Our analysis suggests that as many as six plumage features can be used to separate males of the three taxa (three being diagnostic and the others virtually so), and five features to distinguish females (all of them diagnostic). Morphometric data subjected to a Principal Components Analysis suggest that the three taxa are rather better separated in size and shape than was previously thought, especially amongst males. In some respects Socotran birds more closely resemble Arabian populations (principally in the presence of a white cheek patch), rather than *louisae* of mainland Africa, but are nonetheless readily distinguished from both. This is unsurprising when one considers that most of Socotra's endemic avian taxa are either truly

unique (i.e. species) or are probably best considered as synonyms of African forms (Kirwan in press a,b). Our results demand molecular testing, but provide strong indication that three allospecies, perhaps even full species, are involved, based on the guidelines for assigning species rank of Helbig *et al.* (2002), but marginally weaker evidence for the recognition of more than one species if the quantitative system used by Collar (2006, to be elaborated in full by Collar *et al.* in prep.) is employed. We recommend that *R. socotranus* be henceforth regarded as either three species or one, but suggest that to recognise two species within the genus is either over-estimating or under-estimating biodiversity.

This is the second in a series of papers that re-analyses the taxonomy of birds described from the ancient island of Socotra, which lies close to the Horn of Africa but is politically part of Yemen (the first part considered subspecific limits in *Caprimulgus nubicus*: Kirwan 2004). These notes seek to reawaken interest in taxonomic studies of Socotran birds, specifically to meet the challenge set by Martins (1996), who stated: 'There is a clear need for a review of the avifauna of Socotra which reflects contemporary systematic thinking.' The present contribution considers the taxonomy of the Golden-winged Grosbeak *Rhynchostruthus socotranus*, a bird restricted to northern Somalia, Socotra and southernmost Arabia.

Rhynchostruthus is a monospecific cardueline taxon of somewhat enigmatic affinities (see also Martins 1987). Though its skull structure resembles those of the Asian genera *Rhodopechys* and *Mycerobas* (the possibility of it being a relictual taxon from the Himalayas was noted by Ripley 1954) and the New World *Hesperiphona* (grosbeaks), Fry & Keith (2004) considered *Rhynchostruthus* as being close to *Carduelis* because of their morphological similarities, and even suggested that *Rhynchostruthus* might be better subsumed within *Carduelis*. Dickinson (2003) also considered them close relatives, but maintained two genera. For now, we too consider that the available evidence supports the *status quo*, namely that *Rhynchostruthus* is a sufficiently distinct taxon to merit recognition, albeit closely related to *Carduelis*. Martins (1987) noted the similarities in flight-display between *Rhynchostruthus* and some Eurasian *Carduelis*, whilst Lees-Smith (1986) drew attention to the cardueline body size and colour pattern, but pointed to their dissimilarity to Afrotropical carduelines. Earlier, Voous (1977) had placed it, with *Callacanthus*, between *Serinus* and *Carduelis*, whilst noting, as had Ripley & Bond (1966), the difficulties of determining its relationships (in an epoch prior to the wide-rang-

ing use of molecular techniques to resolve such issues). Work in progress, by Groth (1998), towards a robust phylogeny for the cardueline finches (and Hawaiian honeycreepers) suggests that *R. socotranus* occupies the same clade as many *Serinus* canaries, as well as a number of *Carduelis*, *Loxia* (crossbills) and one of the four species sometimes placed in the genus *Rhodopechys* (*obsoleta*; Desert Finch). Indeed, *Rhynchostruthus* appears to cluster most closely with the latter and *Carduelis sinica* (Oriental Greenfinch).

Three taxa are usually recognised within *Rhynchostruthus*, traditionally at subspecific level: *R. s. socotranus* Sclater & Hartlaub, 1881 (syn. *riebecki* Hartlaub, 1881; endemic to Socotra), *R. s. louisae* Phillips, 1897 (endemic to a small area of northern Somalia; see Ash & Miskell 1998), and *R. s. percivali* Ogilvie-Grant, 1900 (syn. *yemenensis* Ogilvie-Grant, 1913; endemic to south-west Arabia). As was the norm in the late 19th century, all three taxa were originally described as species, but were thereafter widely treated subspecifically, until Fry & Keith (2004), elected to elevate *louisae* (Somali Golden-winged Grosbeak) and *socotranus* including *percivali* (Arabian Golden-winged Grosbeak) to the level of species once again. Furthermore, just prior to this proposal, Sinclair & Ryan (2003), in their African field guide, chose to treat both *louisae* and nominate *socotranus* specifically, the implication being that *percivali* also merits such status, though this taxon is outside the scope of their book and therefore unmentioned therein.

Methods

We acquired mensural data from specimens of all relevant taxa (see Table 3) held at the Natural History Museum (NHM, Tring), as follows: *Rhynchostruthus socotranus socotranus* (Socotra: $n=15$, including eight males); *Rhynchostruthus socotranus louisae* (Somalia: $n=16$, including ten males); and *Rhynchostruthus socotranus percivali* (Saudi

Table 1. Characters useful in discriminating males of Golden-winged Grosbeak *Rhynchostruthus socotranus* taxa. The following were rated as diagnostic on the basis of this evaluation: white cheek-patch, crown colour and underparts pattern. The other characters were rated as near-diagnostic. Numbers in parentheses refer to scoring system following Collar (2006) and Collar *et al.* (in prep.). The right-hand column presents the conservative total under the latter system of all morphological characters.

Tableau 1. Caractères utiles pour distinguer les mâles des taxons du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*. Les caractères suivants ont été considérés comme diagnostiques sur la base de cette évaluation: tache blanche sur la joue, couleur de la calotte et aspect des parties inférieures. Les autres caractères ont été considérés comme quasi diagnostiques. Les chiffres entre parenthèses sont les points accordés à chaque caractère selon la méthode de Collar (2006) et Collar *et al.* (in prep.). La colonne de droite présente le total minimal accordé à l'ensemble des caractères morphologiques en suivant cette méthode.

Taxon	Character						Scoring
	white cheek-patch	crown colour	throat colour	underparts	outermost tail-feather	wing	
<i>socotranus</i>	black border	dusky black	chocolate-black and most extensive	pale grey throughout	distinct yellow fringe	as <i>percivali</i>	
<i>louisae</i>	no white on cheeks (3)	dark greyish (more concolorous with mantle) (1)	chocolate-black, only on throat (1)	plain grey grading to white ventrally (1)	distinct yellow fringe to outer web	solid wing-band, yellow extends nearer to base of secondaries (1)	7
<i>percivali</i>	very narrow brown border (1)	brown (sometimes warmer, even chestnut) (1)	black (largely restricted to chin) (1)	chestnut on throat/ upper breast grading to grey (some have slight white cast to vent) (3)	virtually no yellow fringe (1)	wing-band appears broken because base of outer secondaries dark	7

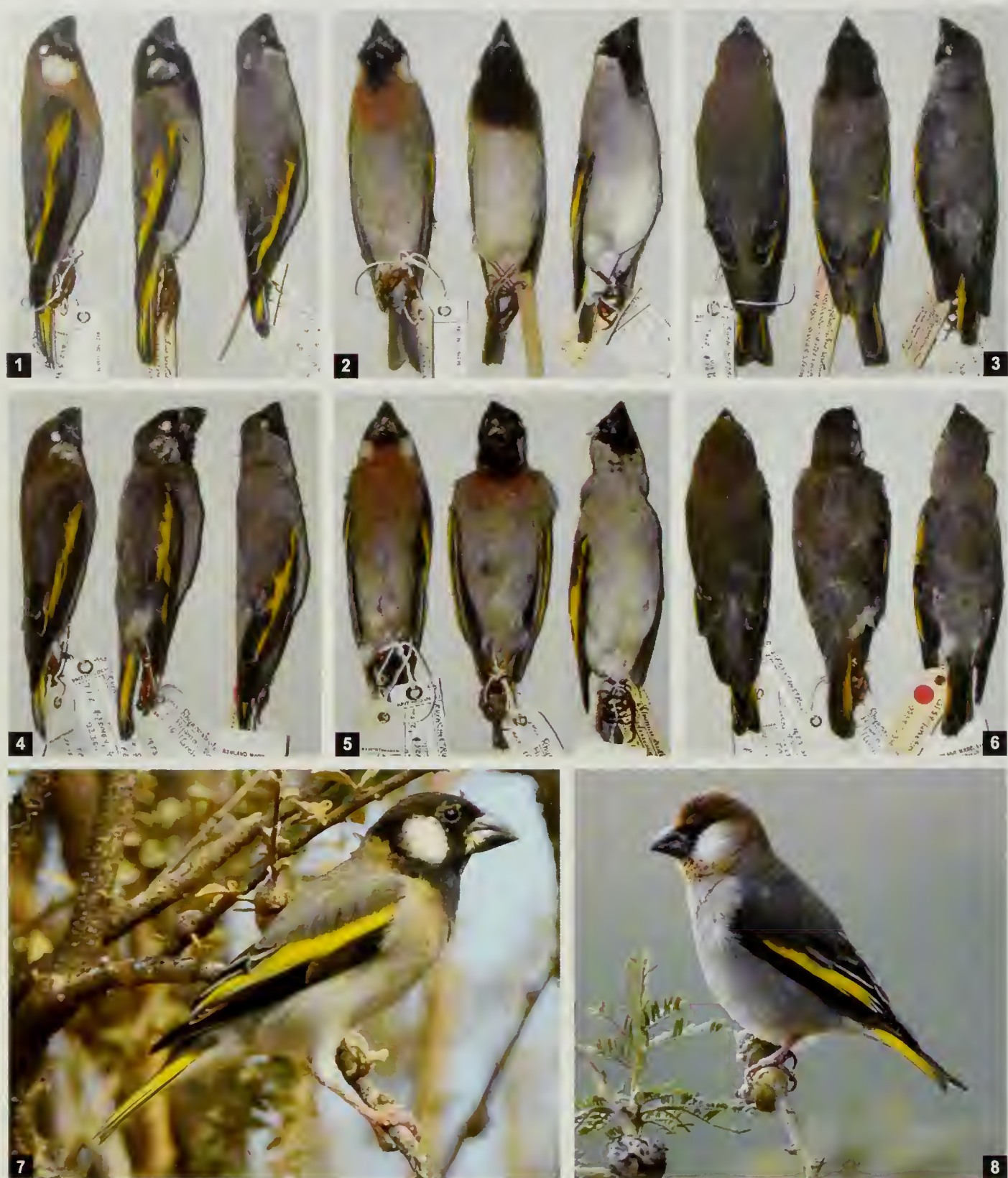
Arabia and Yemen: $n=26$, including 16 males), and the National Museum of Natural History (Smithsonian Institution), Washington DC: *R. s. socotranus* (Socotra: $n=32$, including 21 males); and *R. s. louisae* (Somalia: $n=3$, including one male). The following types were examined: *R. s. socotranus* (NHM 1881.3.21.28), *R. s. louisae* (NHM 1898.4.24.24), *R. s. percivali* (NHM 1900.12.6.1) and '*R. s. yemenensis*' (NHM 1913.8.6.127). Specimens were generally sexed according to label data, but these were checked closely against relevant literature (Clement *et al.* 1993, Fry & Keith 2004) in the case of suspect identifications. The following data were obtained from each specimen: wing-chord (flattened) and tail-length, using a standard metal wing-rule with a perpendicular stop at zero (accurate to 0.5 mm), and culmen-length (to skull) and culmen-depth (at the feathers), using digital callipers (accurate to 0.01 mm). All measurements were taken by GMK.

Notes on plumage variation in both sexes of all three forms of Golden-winged Grosbeak were taken and ranked according to their usefulness in distinguishing the different taxa. There was a clear hierarchy in their relative usefulness. Thus, they were non-statistically rated as being either average

or good, with the latter category being further subdivided into good- and good+ (these subdivisions can be considered as being 'virtually diagnostic' and 'diagnostic'). We also attempted to conservatively score character differences within the context of a comparison of all three taxa using the system elucidated by Collar (2006), which will be fully tabled by Collar *et al.* (in prep.). A broad range of material, pertaining to all three generally recognised forms, was photographed, using a Nikon Coolpix 885 digital camera, in indirect natural light (see Figs. 1–6).

Statistical analyses were performed using the MINITAB programme and PAST (PALaeontological STATistics) was used to generate the Principal Components Analysis (PCA) and compile the figures. All Analysis of Variance (ANOVA) was one-way to evaluate significant mean differences between the different taxa. Specimens for which an incomplete series of mensural data was available were excluded from the statistical analysis.

Field observations of Golden-winged Grosbeaks were made by GMK in Yemen and Socotra in March–April 1993 and by both authors in south-west Oman in March 2005.



Results

Plumage.—A number of plumage characters serve to differentiate the three taxa, namely the presence and pattern of the white cheek-patch, crown colour, throat colour, underpart pattern, the pattern on the outermost tail-feather and, principally in males, the pattern of yellow in the wing. All other characters were found to be useful in discriminating adults of both sexes, but whereas all of

the first-named five were perfectly diagnostic in females, only three were ranked as diagnostic in males, i.e. the white cheek-patch, crown colour and underpart pattern. Specific details of the plumage of each taxon in relation to these characters are presented in Tables 1–2.

Juvenile males, of which we have examined very few of any form, are distinguished from adults by the heavily dark-streaked upperparts

including crown and mantle in *socotranus*, but *louisae* appears unstreaked in this plumage, whereas *percivali* clearly resembles *socotranus* at this age, but the only bird examined by us had less clear streaking on the mantle. The underparts of juvenile males are very pale, with an almost unstreaked lower belly / ventral region in *socotranus* (a feature also apparent in three juvenile females of this form), but *percivali* is more heavily streaked throughout the underparts (like *louisae*). Some younger birds, of both sexes, in *socotranus* which have achieved mainly adult plumage (in May) retain some streaking on the breast and, in one case, even on the mantle (late April). For further remarks on the younger plumages of *socotranus* see Gedeon & Neumann (2004).

Captions to plates on opposite page

Figures 1–3. Lateral, ventral and dorsal views of male Golden-winged Grosbeaks *Rhynchostruthus socotranus*, left to right: *R. s. percivali*, from Ta'izz, Yemen, December 1948; *R. s. socotranus*, from Adho Dimellus, Socotra, February 1899; and *R. s. louisae*, from Wadi Mirso (=Marso), Somalia, November 1917 (Guy M. Kirwan, © The Natural History Museum, Tring)

Vues latérales, ventrales et dorsales de spécimens mâles du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*, de gauche à droite: *R. s. percivali*, de Ta'izz, Yémen, décembre 1948; *R. s. socotranus*, de Adho Dimellus, Socotra, février 1899; et *R. s. louisae*, de Wadi Mirso (=Marso), Somalie, novembre 1917 (Guy M. Kirwan, © The Natural History Museum, Tring)

Figures 4–6. Lateral, ventral and dorsal views of female Golden-winged Grosbeaks *Rhynchostruthus socotranus*, left to right: *R. s. percivali*, from Ta'izz, Yemen, December 1948; *R. s. socotranus*, from Hijama, Socotra, March 1953; and *R. s. louisae*, from Wadi Mirso (=Marso), Somalia, November 1917 (Guy M. Kirwan, © The Natural History Museum, Tring)

Vues latérales, ventrales et dorsales de spécimens femelles du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*, de gauche à droite: *R. s. percivali*, de Ta'izz, Yémen, décembre 1948; *R. s. socotranus*, de Hijama, Socotra, mars 1953; et *R. s. louisae*, de Wadi Mirso (=Marso), Somalie, novembre 1917 (Guy M. Kirwan, © The Natural History Museum, Tring)

Figure 7. Golden-winged Grosbeak / Grand-verdier à ailes d'or *Rhynchostruthus socotranus socotranus*, Diksam Plateau, Socotra, 3 April 2007 (Barrie Rose)

Figure 8. Golden-winged Grosbeak / Grand-verdier à ailes d'or *Rhynchostruthus socotranus percivali*, near Kawkaban, Yemen, 23 March 2007 (P. Ryan)

Mensural characters.—The analyses revealed the distinctiveness of *louisae*, which is significantly shorter winged, shorter tailed and smaller billed than either *percivali* or *socotranus*. Furthermore, *socotranus* is significantly shorter winged and has a less deep-based bill than *percivali* (Tables 3–5; Figs. 9–10). The PCA graphs (Figs. 9–10) reveal the degree of separation amongst the three taxa, which is particularly marked in males, but less so in females.

Moult.—Virtually nothing has previously been published on moult in the genus *Rhynchostruthus* (see, e.g., Gedeon & Neumann 2004). There was no evidence of wing moult in autumn in five specimens of *louisae* that were in their second calendar year at least (two males, two females, one unsexed), taken between 5 and 21 September. All were in fresh plumage, suggesting that moult in these birds may have taken place prior to this period. A further eight specimens of the same age, obtained between October and December, were also all in reasonably fresh plumage with little sign of wear. A single similar-age female, taken on 31 January, was worn but not heavily so, whilst single male and female specimens taken in early to mid May showed no evidence of body moult.

Of 21 specimens of *percivali* obtained in December–January, individuals of both sexes in at least their second calendar year also showed no sign of ongoing moult and were in reasonably fresh plumage with relatively little sign of wear. Two specimens of *percivali* obtained between 25 February and 3 March in at least their second calendar year (at the same time that specimens of *socotranus* were in arrested moult; see below) showed no moult activity and were in fresh plumage with no sign of significant feather wear.

Seven (four males and three females) of nine *socotranus* in at least their second calendar year, obtained between 12 February and 23 March, showed arrested wing moult. In six of these all of the tertials had been replaced, in all seven between two and six secondaries had been renewed, and in one bird four primaries had been replaced; the remaining unmoulted wing-feathers in all these birds were heavily worn. The two birds not showing arrested moult had fresh remiges and rectrices, and there was evidence of recently completed moult in the undertail-coverts of one bird.

Table 2. Characters useful in discriminating females of Golden-winged Grosbeak *Rhynchostruthus socotranus* taxa. All characters were considered diagnostic. Note that the wing pattern in all three taxa was identical to that of the respective males, but the differences are even less marked. Numbers in parentheses refer to scoring system following Collar (2006) and Collar *et al.* (in prep.). The right-hand column presents the conservative total under the latter system of all morphological characters.

Tableau 2. Caractères utiles pour distinguer les femelles des taxons du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*. Tous les caractères ont été considérés comme diagnostiques. Notez que le pattern de l'aile des trois taxons était identique à ceux des mâles respectifs, mais les différences sont encore moins marquées. Les chiffres entre parenthèses sont les points accordés à chaque caractère selon la méthode de Collar (2006) et Collar *et al.* (in prep.). La colonne de droite présente le total minimal accordé à l'ensemble des caractères morphologiques en suivant cette méthode.

Taxon	Character					Scoring
	white cheek-patch	crown colour	throat colour	underparts	outermost tail-feather	
<i>socotranus</i>	narrow dark border, flammulated grey at rear	dull blackish becoming brown-grey at rear	dull blackish and most extensive	brown upper breast, inclining to pale grey and whiter on undertail-coverts	distinct yellow fringe	
<i>louisae</i>	no white on cheeks (2)	grey-brown (almost concolorous with mantle) (1)	dull blackish, restricted to chin (1)	entirely grey becoming paler on belly and white on undertail-coverts (1)	distinct yellow fringe	5
<i>percivali</i>	brown-grey border, flammulated grey (1)	brown inclining to chestnut on forehead (1)	largely brown with tiny black chin (2)	solid (darker) grey with white undertail-coverts (1)	no distinct yellow fringe (none on shaft) (1)	6

Discussion

Taxonomic treatment

Allopatric taxa, as noted by Helbig *et al.* (2002), always present particularly problematic cases when endeavouring to ascertain whether they should be regarded specifically, for as these authors state: 'Assignment of species rank in such cases will necessarily be based on hypothesis, rather than on proven facts.' All three constituents of *Rhynchostruthus* are clearly rather close in general morphology, ecology and habits. Nonetheless, they are also easily diagnosable in virtually all plumages. In addition, both sexes clearly separate using a multivariate statistical analysis of mensural data (see Table 3, and Figs. 9–10). In sum, it seems that the three *Rhynchostruthus* demand recognition under any of the pattern-defined species concepts currently operating (see Sluys & Hazevoet 1999) and have certainly achieved allospecies status, but whether they have achieved full species rank under the modern definition of the Biological Species Concept (BSC) should perhaps await the results of molecular analysis, notwithstanding the decision of Fry & Keith (2004) to treat the complex as two species. In contrast, all of the taxa discussed here would surely be recognised as species under the framework of the Metapopulation Lineage Concept (or General

Species Concept), application of which, it was argued recently by de Queiroz (2005), not only provides a means of unifying how modern-day biologists diagnose 'species', but also returns more closely to Mayr's original conceptualisation of what constitutes a species, rather than merely focusing on the attribute of reproductive isolation.

Because of a perception that the Helbig *et al.* (2002) guidelines set a threshold too low for assigning species status, especially for allopatric taxa (Collar 2004), Collar *et al.* (in prep.) will present an alternative system for use by those seeking also to work within the confines of an updated BSC. Working from this, Collar (2006) presented a revision of species limits in some Asian babblers using quantitative scoring to assign species status on the basis of plumage, morphometric and vocal characters. In cases of polytypy, Collar (2006) compared the morphologically closest taxa, whereas in submitting *Rhynchostruthus* to such a 'test' we have deliberately endeavoured, as far as possible, to score *percivali* and *louisae* in comparison to *socotranus* for both sexes separately (see Tables 1 and 2) and with a degree of conservatism. Thus, for a taxon to score at all, it was required to differ in any given feature from *both* other taxa being analysed, rather than merely from the closest in morphology (given that all three are

Table 3. Mensural data for the three taxa of Golden-winged Grosbeak *Rhynchostruthus socotranus* with significance levels (one-way analysis of variance ANOVA).

Tableau 3. Mensurations des trois taxons du Grand-verdier à ailes d'or *Rhynchostruthus socotranus* avec niveaux de signification (analyse ANOVA de variance à un facteur).

	<i>percivali</i> mean ± SD (n)	<i>socotranus</i> mean ± SD (n)	<i>louisae</i> mean ± SD (n)	ANOVA
Wing	male	90.78 ± 2.21 (18)	86.82 ± 1.34 (30)	82.30 ± 2.06 (10) ***
	female	85.60 ± 1.71 (10)	83.29 ± 2.05 (17)	79.25 ± 2.38 (8) ***
Tail	male	56.06 ± 2.79 (17)	56.07 ± 2.50 (30)	50.30 ± 1.64 (10) ***
	female	53.70 ± 2.06 (10)	53.00 ± 2.37 (17)	50.00 ± 2.62 (8) **
Bill-length	male	18.55 ± 0.68 (18)	18.56 ± 0.64 (29)	15.84 ± 0.55 (10) ***
	female	17.26 ± 1.14 (10)	17.56 ± 0.67 (17)	14.99 ± 1.09 (8) ***
Bill-depth	male	11.99 ± 0.43 (17)	12.68 ± 0.61 (29)	10.89 ± 0.43 (10) ***
	female	10.92 ± 0.55 (10)	11.74 ± 0.44 (16)	10.09 ± 0.38 (8) ***

** = $P < 0.01$ *** = $P < 0.001$

close both in geographical and morphological terms). In the present case, it is only possible to score morphological and morphometric characters, as vocal data that can be subject to meaningful analysis are lacking. Taking the highest available score for each taxon (i.e. from either sex) gives totals of *louisae* = 7 and *percivali* = 7, to which scores we would also allot a further point for their reasonably well-differentiated morphometrics. In

other words, all three taxa would achieve species status under the Collar *et al.* system (which determines 7 as the lowest score required to allot such a ranking). It should be emphasised that all taxa achieved a score of 2 or 3 for at least one feature. (The Collar *et al.* guidelines do not admit species-level recognition for any taxon that does not possess at least one character scoring in excess of 1, regardless of whether a total 7 is achieved.)

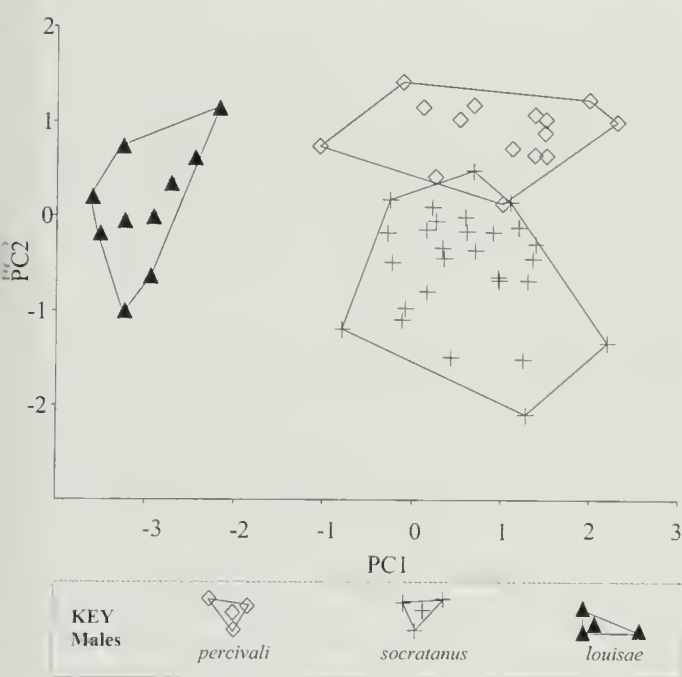


Figure 9. Plot of first (PC1) and second (PC2) principle components for a Principle Components Analysis of four morphometric measurements of males of three taxa of Golden-winged Grosbeak *Rhynchostruthus socotranus*.

Position des premières (PC1) et secondes (PC2) composantes principales pour une Analyse en Composantes Principales de quatre mensurations morphométriques de mâles des trois taxons du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*.

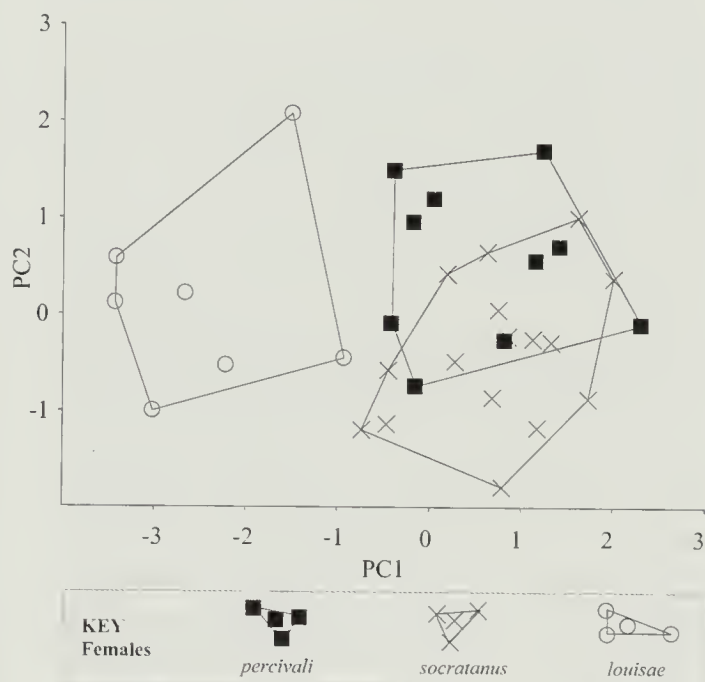


Figure 10. Plot of first (PC1) and second (PC2) principle components for a Principle Components Analysis of four morphometric measurements of females of three taxa of Golden-winged Grosbeak *Rhynchostruthus socotranus*.

Position des premières (PC1) et secondes (PC2) composantes principales pour une Analyse en Composantes Principales de quatre mensurations morphométriques de femelles des trois taxons du Grand-verdier à ailes d'or *Rhynchostruthus socotranus*.

Table 4. Principle component (PC) loadings on mensural characters of male Golden-winged Grosbeaks *Rhynchostruthus socotranus* for the three taxa.

Tableau 4. Importance des composantes principales (PC) de mensurations de mâles du Grand-verdier à ailes d'or *Rhynchostruthus socotranus* pour les trois taxons.

Character	PC1	PC2	PC3	PC4
Wing	0.483	0.679	-0.185	-0.521
Tail	0.523	0.069	0.798	0.291
Bill-length	0.533	-0.057	-0.571	0.622
Bill-depth	0.457	-0.729	-0.052	-0.507
Eigen values	2.682	0.673	0.379	0.189
% variance	68.36	17.15	9.67	4.82

Two of the authors of the new guidelines, N. J. Collar and L. D. C. Fishpool, independently examined and scored the material in Tring and arrived at the following conclusions. They scored *louisae* 1 for smaller bill, 2 for different face pattern (crown to chin), 2 for different underparts (throat and upper breast), 1 for full yellow wing-band, 1 for more yellow in tail and 1 for greater sexual uniformity, = 7. When rating *socotranus* against *percivali*, they ranked these taxa as scoring 3 for different face pattern, 3 for different upper undersides and 1 for different belly coloration, = 7.

Given the paucity of vocal data for the three taxa, indeed the complete lack of such information for *louisae*, it is currently impossible to investigate whether any such differences exist amongst the different forms of *Rhynchostruthus*. Accepting this, and the lack of molecular analyses, we recommend that *socotranus*, *louisae* and *percivali* be regarded as either one species (following traditional taxonomy) or three (as, presumably, in Sinclair & Ryan 2003), but consider that separation into two species (following Fry & Keith 2004) does not provide a rational taxonomic solution to the variation exhibited by these taxa. Whilst *louisae* is plainly the most obviously different of the three (due to its lacking a white cheek-patch), *socotranus* and *percivali* are both easily diagnosable too. It is also probably the case that their evolutionary histories have long been separate.

Socotra was originally part of the African–Arabian tectonic plate (it forms a continuation of the Somali peninsula) and probably became isolated by the same series of dislocations during the break-up of Gondwana that produced the Gulf of Aden in the late Tertiary, at least 10 million years ago (Laughton *et al.* 1970). It is thought that the Haggier mountains have

remained above sea level since the Mesozoic (Gregory 1903, Uvarov & Popov 1958, Wrang 2003), thereby acting as a refugium for terrestrial fauna and flora. Nonetheless, for an unknown period following the continental separation, Socotra apparently formed part of a landbridge between Africa and Arabia, thus also permitting some faunal interchange. Ornithologically, overall, Socotra has long been considered Afrotropical (Chapin 1932, Ripley & Bond 1966), but floristically the archipelago is more complex (Ripley & Bond 1966, references therein). Our ongoing work on the taxonomy of Socotran birds reveals that several taxa previously considered endemic to the island are better considered synonyms of African or even wider-ranging African and Arabian forms (Kirwan in press b), whilst in other respects diversity in this ancient archipelago has been underestimated (Kirwan in press a).

Validity of race yemenensis

We must now discuss the validity of *R. s. yemenensis* (type from Wasel [=Wasil: Brooks *et al.* 1987], in montane northern Yemen), which was described (as a subspecies of *percivali*, at that time considered specifically) on the basis of it lacking black on the forehead, having the head and nape brighter rufous-brown, a browner mantle and darker grey rump and uppertail-coverts. The vast majority of those specimens of *Rhynchostruthus* from Yemen held in NHM are from the putative range of *yemenensis*. At the time of description, *percivali* was considered restricted to the Hadramaut (in eastern Yemen; type-locality Yeshbun [=Yashbum: Porter *et al.* 1996]). Some *percivali* from Ta'izz and Lodar (=Lawdar), the latter locality very close to the type-locality of *percivali* but the former closer to that of *yemenensis*,

Table 5. Principle component (PC) loadings on mensural characters of female Golden-winged Grosbeaks *Rhynchostruthus socotranus* for the three taxa.

Tableau 5. Importance des composantes principales (PC) de mensurations de femelles du Grand-verdier à ailes d'or *Rhynchostruthus socotranus* pour les trois taxons.

Character	PC1	PC2	PC3	PC4
Wing	0.5386	0.2569	-0.7166	-0.3611
Tail	0.4175	0.7446	0.4845	0.191
Bill-length	0.5371	-0.4152	-0.1109	0.7258
Bill-depth	0.4971	-0.4551	0.4893	-0.5535
Eigen values	2.399	0.830	0.429	0.223
% variance	61.84	21.38	11.05	5.73

have a black frontal band to a greater or lesser extent. Three males from Ta'izz, taken in December 1948, range from having no black (1965M.17017) or little black (1965M.17021) to a reasonably well-developed black frontal black band (1965M.17019). Birds from Amiri district are also obviously variable in the amount of black. The other features used to describe *yemenensis* appear to be similarly variable in the material to hand, leading us to agree with those previous authors who have regarded it as a synonym of *percivali*.

Gaps in our knowledge

Other than the data to hand concerning external morphology and mensural characteristics it is difficult to make any comparisons between the three taxa. Available knowledge of Arabian and Socotran on the one hand, and Somali birds on the other was ably summarised by Fry & Keith (2004). For *louisae* our data are virtually non-existent; to all intents and purposes its natural history and even its vocalisations are entirely unknown. Such a paucity of information is wholly unsurprising given the extreme lack of field work in the country in recent years (see Ash & Miskell 1998), but the majority of the ranges of *percivali* and *socotranus*, the latter especially, are also very little visited by ornithologists and birdwatchers. Within the last decade there has been scarcely any such activity in Yemen (the bulk of the range of *percivali*) and whilst Oman has enjoyed much greater attention during this period, *Rhynchostruthus* is distinctly uncommon in that country and confined to an area that is comparatively less visited (Eriksen & Sargeant 2000), though it is rather commoner in the wooded Mahrah in adjacent eastern Yemen (Martins *et al.* 1996). On the other

hand, since 1993 ornithological visits to Socotra have become decidedly more regular, but this is merely relative; prior to that date, no dedicated avifaunal work had been undertaken on the island since the 1960s! Where limited comparisons are possible, namely between *socotranus* and *percivali*, the data appear to show much overlap. Courtship displays are seemingly identical and vocally the two appear very similar (Fry & Keith 2004; GMK pers. obs.), though more data are welcome. Jennings (1995) suggested that Arabian birds have a prolonged breeding season, but many data on breeding biology are still lacking for both *socotranus* and *percivali* (see Fry & Keith 2004, Gedeon & Neumann 2004). However, we suspect that Socotran birds, on average, almost certainly breed slightly earlier than those in Oman, at least, but this is nothing more than a reflection of prevailing climatic factors and certainly not taxonomically significant.

Conservation implications of a revised taxonomy

If three rather one species of *Rhynchostruthus* were to be acknowledged, could this have important consequences for conservation? Golden-winged Grosbeak *sensu lato* was considered a candidate species for inclusion in the African Red Data Book (Collar & Stuart 1985), but was only ranked as Least Concern two decades later (BirdLife International 2004). Currently, *percivali* is known from six Important Bird Areas (IBAs), *socotranus* from two (Evans 1994), and *louisae* from three IBAs (Robertson 2001).

The taxon *percivali* is generally scarce and difficult to locate even at known sites, with the exception perhaps of those in Yemen (R. F. Porter *in litt.* 2006), and its population is estimated at c.3,000 pairs (i.e. c.9,000 individuals including

juveniles and non-breeders), with 500 pairs in Saudi Arabia, 500 pairs in Oman (although this may be optimistic: J. Atkins *in litt.* 2006), and c.2,000 pairs in Yemen (M. C. Jennings *in litt.* 2006; information from Atlas of the Breeding Birds of Arabia). There have not been any records from the region between Aden and Mukallah since 1950, despite better observer coverage, suggesting that it is very rare there or that its range has contracted (M. C. Jennings *in litt.* 2006). Although the species' habitat has been degraded in Yemen, it appears to be no more abundant in south-west Saudi Arabia where the habitat is more intact. Given uncertainty over whether the taxon is declining, it would probably warrant Near Threatened status (almost meeting criterion C2aii) if assessed separately.

Taxon *socotranus* is widespread on Socotra, where it is locally common, with a population estimate of c.6,500 individuals (R. F. Porter *in litt.* 2006). None of its habitats appear to be threatened, so this taxon would arguably qualify as Least Concern if assessed separately, albeit with a caveat that any evidence of declines or threats would qualify it for Near Threatened or even Vulnerable.

The status of *louisae* appears to be especially poorly known, owing in large part to a lack of observers within its range. Though formerly quite common, at least until the 1930s, it now appears uncommon and difficult to find, even in areas where it might be expected, with few recent records. It may be declining, perhaps due to habitat loss (particularly in the western part of its range), but poor rainfall in recent years may be more important, though there were good rains in 2005–06 (J. Miskell *in litt.* 2006). There are no published population estimates, but given its small range and apparent scarcity, a precautionary assessment might place numbers below 10,000 individuals, in several subpopulations. If assessed separately, *louisae* would appear to merit Near Threatened status, almost meeting criterion C2a(ii).

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